

**I CLAIM:**

1. A thermally activated, chemically based marking method comprising steps of:

electrostatically applying a layer of an energy absorbing marking material to a conductive or dielectric substrate to be marked; and irradiating said layer with a radiant energy beam having a wavelength selected to excite said energy absorbing material in accordance with the form of a marking to be applied, thereby forming a marking layer atop said substrate.

2. The method of claim 1, further comprising a step of providing a laminar air flow across said substrate during the irradiating step.

3. The method of claim 1, wherein said marking material comprises at least one metal compound.

4. The method of claim 3, wherein said metal compound is an oxide.

5. The method of claim 4, wherein said compound is a mixed metal oxide.

6. The method of claim 3, wherein said compound is a sulfide.

7. The method of claim 3, wherein said compound is a sulfate.

1        8.    The method of claim 3, wherein said compound is a  
2 carbonate.

3        9.    The method of claim 1, wherein said marking  
4 material comprises Kaolin clay.

5        10.   The method of claim 1, wherein said marking  
6 material comprises an energy absorbing enhancer.

7        11.   The method of claim 1, wherein said marking  
8 material comprises at least one colorant.

9        12.   The method of claim 10 wherein said energy  
10 absorbing enhancer comprises carbon black.

11       13.   The method of claim 1, wherein said substrate  
12 comprises materials selected from the group consisting of  
13 metals, glasses, ceramics and plastics.

14       14.   The method of claim 13, wherein said substrate  
15 comprises at least one metal.

16       15.   The method of claim 13, wherein said substrate  
17 comprises at least one glass.

18       16.   The method of claim 1, wherein said marking  
19 material comprises at least one glass frit material.

20       17.   The method of claim 16, wherein said glass frit  
21 material comprises at least one oxide selected from oxides  
22 of alkali metals, alkaline earth metals, silicon, boron and  
23 transition metals.

1        18. The method of claim 1, wherein said marking  
2 material comprises at least one glass frit material and at  
3 least one metal compound.

4        19. The method of claim 11, wherein said marking  
5 material comprises at least one organic pigment.

6        19. The method of claim 1, wherein said marking  
7 material is applied by direct electrostatic coating of a  
8 conductive substrate.

9        20. The method of claim 1, wherein said marking  
10 material is applied by direct electrostatic coating of a  
11 dielectric substrate, after said substrate has been coated  
12 with a layer of conductive material.

13       21. The method of claim 1, wherein said marking  
14 material is applied as dry particles.

15       22. The method of claim 1, wherein said marking  
16 material is applied as liquid droplets.

17       23. The method of claim 1, wherein said marking  
18 material is electrostatically applied in the form of a  
19 marking to be applied to said substrate.

20       24. The method of claim 1 wherein said radiant energy  
21 beam is produced by a laser, diode laser or diode-pumped  
22 laser.

23       25. A substrate as marked by the method of claim 1.

24       26. A thermally activated, chemically based marking  
25 method comprising steps of:

1           electrostatically applying a layer of mixed metal  
2           oxide material containing an energy absorbing  
3           enhancer to a metal substrate; and  
4           irradiating said layer with a radiant energy beam  
5           having a wavelength selected to excite the metal  
6           oxide material and/or said energy absorbing  
7           enhancer in accordance with the form of a  
8           marking to be applied, thereby forming a marking  
9           layer atop the substrate.

10          27. The method of claim 26 further comprising the step  
11 of providing a laminar air flow across the substrate during  
12 the irradiating step.

13          28. The method of claim 26, wherein the mixed metal  
14 oxide material comprises at least one colorant, and the  
15 energy absorbing enhancer comprises carbon black.

16          29. The method of claim 26, wherein the radiant energy  
17 beam comprises a laser beam having an energy level ranging  
18 between 1 and 30 watts, a spot size ranging between 5 and  
19 200 microns, and a marking speed along the substrate ranging  
20 between 25 and 1000mm/sec.

21          30. The method of claim 26, wherein the layer of mixed  
22 metal oxide material has a thickness ranging between 5 and  
23 500 microns.

24          31. The method of claim 26 wherein said irradiating  
25 step is started at a room temperature of about 70° F.

1        32. A metal substrate as marked by the process  
2 according to claim 26.

3        33. A thermally activated chemically based marking  
4 method comprising steps of:

5            electrostatically applying a layer of mixed metal  
6            oxide material containing an energy absorbing  
7            enhancer to a substrate selected from the group  
8            consisting of aluminum, brass, chrome, copper,  
9            nickel, steel, stainless steel, tin, glass,  
10           ceramics, porcelain, and plastics; and  
11           irradiating said layer with a radiant energy beam  
12           having a wavelength selected to excite the  
13           energy absorbing enhancer in accordance with the  
14           form of a marking to be applied, thereby forming  
15           a marking layer atop the substrate.

16        34. The method of claim 33 further comprising the step  
17 of providing a laminar air flow across the substrate during  
18 the irradiating step.

19        35. The method of claim 33, wherein said mixed oxide  
20 material is applied as dry particles.

21        36. The method of claim 33, wherein said mixed oxide  
22 material is applied as liquid droplets.

23        37. The method of claim 33, wherein the energy  
24 absorbing enhancer comprises carbon black.

1        38. The method of claim 33, wherein the radiant energy  
2 beam comprises a laser beam having an energy level ranging  
3 between 1 and 30 watts, a spot size ranging between 5 and  
4 200 microns, and a marking speed along the substrate ranging  
5 between 25 and 1000mm/sec.

6        39. The method of claim 33, wherein the layer of mixed  
7 metal oxide material has a thickness ranging between 5 and  
8 500 microns.

9        40. The method of claim 33 wherein said irradiating  
10 step is started at a room temperature of about 70° F.

11       41. The method of claim 33, wherein the mixed metal  
12 oxide material comprises a colorant.

13       42. A substrate material as laser marked by the process  
14 according to claim 33.

15       43. A thermally activated, chemically based marking  
16 method comprising steps of:

17        electrostatically applying a layer of mixed metal  
18        oxide material containing an energy absorbing  
19        enhancer to a substrate to be marked in the form  
20        of a marking to be applied; and  
21        irradiating said layer with a radiant energy beam  
22        having a wavelength selected to excite the  
23        energy absorbing enhancer, thereby forming a  
24        marking layer atop the substrate.

1        44. The method of claim 43, further comprising the step  
2 of providing a laminar air flow across the substrate during  
3 the irradiating step.

4        45. The method of claim 43, wherein said mixed metal  
5 oxide material is applied as dry particles.

6        46. The method of claim 43, wherein said mixed metal  
7 oxide material is applied as liquid droplets.

8        47. The method of claim 43, wherein the energy  
9 absorbing enhancer comprises carbon black.

10       48. The method of claim 43, wherein the radiant energy  
11 beam comprises a laser beam having an energy level ranging  
12 between 1 and 30 watts and a marking speed along the  
13 substrate ranging between 25 and 1000mm/sec.

14       49. The method of claim 43, wherein the layer of metal  
15 oxide material has a thickness ranging between 5 and 500  
16 microns.

17       50. The method of claim 43, wherein the irradiating  
18 step is started at a room temperature of about 70° F.

19       51. The method of claim 43, wherein the mixed metal  
20 oxide material comprises a colorant.

21       52. A substrate material as marked by the process  
22 according to claim 43.

23       53. A thermally activated chemically based marking  
24 method comprising steps of:

1           electrostatically applying a layer having a metal  
2           oxide component and comprising an energy  
3           absorbing enhancing component to a metal  
4           substrate; and  
5           irradiating said layer with a radiant energy beam  
6           having a wavelength selected to excite the  
7           energy absorbing enhancing component, thereby  
8           forming an adhered marking layer atop the  
9           substrate.

10         54. A thermally activated, chemically based marking  
11         method comprising steps of:

12           electrostatically applying a layer having a mixed  
13           metal oxide component and an energy absorbing  
14           enhancing component to a substrate selected from  
15           the group consisting of aluminum, brass, chrome,  
16           copper, nickel, steel, tin, glass, ceramics, and  
17           plastics; and  
18           irradiating said layer with a radiant energy beam  
19           having a wavelength selected to excite the  
20           energy absorbing enhancing component, thereby  
21           forming an adhered marking layer atop the  
22           substrate.

23         55. A thermally activated chemically based marking  
24         method comprising steps of:



1           electrostatically applying a material containing at  
2           least one metal oxide comprising an energy  
3           absorbing enhancing component to a substrate to  
4           be marked in the form of a marking to be  
5           applied; and  
6           irradiating said layer with a radiant energy beam  
7           having a wavelength selected to excite the  
8           energy absorbing enhancing component, thereby  
9           forming a marking layer atop the substrate.

10          56. A thermally activated chemically based marking  
11 method comprising steps of:

12           electrostatically applying a layer of a marking  
13           material comprising at least one metal compound  
14           to a markable substrate comprising at least one  
15           material selected from the group consisting of  
16           metals, glasses, ceramics and plastics; and  
17           irradiating said layer with a radiant energy beam  
18           having a wavelength selected to be absorbed by  
19           said marking material, thereby forming a bonded  
20           marking layer atop the substrate.

21          57. The method of claim 56, wherein said metal compound  
22 comprises a metal oxide.

23          58. The method of claim 57, wherein said metal compound  
24 is a mixed metal oxide.

1        59. The method of claim 56, wherein said metal compound  
2 is a sulfide.

3        60. The method of claim 56, wherein said metal compound  
4 is a sulfate.

5        61. The method of claim 56, wherein said metal compound  
6 is a carbonate.

7        62. The method of claim 56, wherein said marking  
8 material further comprises at least one energy absorbing  
9 enhancing component.

10       63. The method of claim 56, wherein said marking  
11 material comprises at least one colorant or pigment.

12       64. The method of claim 63, wherein said marking  
13 material comprises at least one organic pigment.

14       65. A thermally activated chemically based marking  
15 method comprising the steps of:

16        electrostatically applying a layer of glass frit  
17        material containing an energy absorbing enhancer  
18        to a glass substrate; and  
19        irradiating said layer with a radiant energy beam  
20        having a wavelength selected to excite the  
21        energy absorbing enhancer in accordance with the  
22        form of a marking to be applied, thereby forming  
23        a bonded and permanent marking layer atop the  
24        substrate which is visible in contrast with the  
25        substrate; and

1            wherein the layer of glass frit material has a  
2            thickness ranging between 5 and 500 microns.

3            66. The method of claim 65, further comprising the step  
4 of providing a laminar air flow across the substrate during  
5 the irradiating step.

6            67. The method of claim 65, wherein said glass frit  
7 material is applied as dry particles.

8            68. The method of claim 65, wherein said glass frit  
9 material is applied as liquid droplets.

10           69. The method of claim 65, wherein the glass frit  
11 material further comprises a borosilicate glass and the  
12 energy absorbing enhancer comprises carbon black.

13           70. The method of claim 65, wherein the radiant energy  
14 beam comprises a laser beam having an energy level ranging  
15 between 1 and 30 watts, a spot size ranging between 5 and  
16 200 microns, and a marking speed along the substrate ranging  
17 between 25 and 1000mm/sec.

18           71. The method of claim 65, wherein said irradiating  
19 step is started at a room temperature of about 70° F.

20           72. The method of claim 65, wherein the glass frit  
21 material further comprises a colorant.

22           73. The method of claim 72, wherein said colorant  
23 comprises at least one organic pigment.

24           74. A glass material as marked by the process according  
25 to claim 65.

1        75. A thermally activated chemically based marking  
2 method comprising the steps of:  
3        electrostatically applying a layer of glass frit  
4        material containing an energy absorbing enhancer  
5        to a metal substrate; and  
6        irradiating said layer with a radiant energy beam  
7        having a wavelength selected to excite the  
8        energy absorbing enhancer in accordance with the  
9        form of a marking to be applied, thereby forming  
10       a bonded and permanent marking layer atop the  
11       substrate which is visible in contrast with the  
12       substrate; and  
13       wherein the layer of glass frit material has a  
14       thickness ranging between 5 and 500 microns.

15       76. The method of claim 75 further comprising the step  
16 of providing a laminar air flow across the substrate during  
17 the irradiating step.

18       77. The method of claim 75, wherein the glass frit  
19 material comprises a borosilicate glass, and the energy  
20 absorbing enhancer comprises carbon black.

21       78. The method of claim 75, wherein the radiant energy  
22 beam comprises a laser having an energy level between 1 and  
23 30 watts, a spot size ranging between 5 and 200 microns, and  
24 a marking speed along the substrate ranging between 25 and  
25 1000mm/sec.

1        79. The method of claim 75 wherein said irradiating  
2 step is started at a room temperature of about 70° F.

3        80. The method of claim 75, wherein said glass frit  
4 material is applied as dry particles.

5        81. The method of claim 75, wherein said glass frit  
6 material is applied as liquid droplets.

7        82. The method of claim 75, wherein the glass frit  
8 material further comprises a colorant.

9        83. A metal substrate as marked by the process  
10 according to claim 75.

11       84. A thermally activated chemically based marking  
12 method comprising the steps of:

13        electrostatically applying a layer of glass frit  
14            material containing an energy absorbing enhancer  
15            to a substrate selected from the group  
16            consisting of glass, ceramic, porcelain,  
17            aluminum, brass, steel, stainless steel and tin;  
18            and

19        irradiating said layer with a beam having a  
20            wavelength selected to excite the energy  
21            absorbing enhancer in accordance with the form  
22            of a marking to be applied, thereby forming a  
23            bonded and permanent marking layer atop the  
24            substrate which is visible in contrast with the  
25            substrate.

1        85. A thermally activated, chemically based marking  
2 method comprising the steps of:  
3        electrostatically applying a layer of marking  
4        material comprising at least one of a mixed  
5        organic pigment material and an energy absorbing  
6        enhancer to a plastic substrate; and  
7        irradiating said layer with a radiant energy beam  
8        having a wavelength selected to excite the  
9        energy absorbing enhancer in accordance with the  
10       form of a marking to be applied, thereby forming  
11       a bonded and permanent marking layer atop the  
12       substrate which is visible in contrast with the  
13       substrate.

14       86. The method of claim 85, further comprising the step  
15 of providing a laminar air flow across the substrate during  
16 the irradiating step.

17       87. The method of claim 85, wherein said organic  
18 pigment material comprises carbon black.

19       88. The method of claim 85, wherein the energy  
20 absorbing enhancer comprises carbon black.

21       89. The method of claim 85, wherein the radiant energy  
22 beam comprises a laser beam having an energy level ranging  
23 between 1 and 30 watts, a spot size ranging between 5 and  
24 200 microns, and a marking speed along the substrate ranging  
25 between 25 and 1000mm/sec.

1        90. The method of claim 85, wherein the layer of mixed  
2 organic pigment material has a thickness ranging between 5  
3 and 500 microns.

4        91. The method of claim 85 wherein said irradiating  
5 step is started at a room temperature of about 70° F.

6        92. The method of claim 85, wherein said organic  
7 pigment material is applied as dry particles.

8        93. The method of claim 85, wherein said organic  
9 pigment material is applied as liquid droplets.

10       94. A plastic substrate material as marked by the  
11 process according to claim 85.

12       95. A thermally activated chemically based marking  
13 method comprising the steps of:

14        electrostatically applying a layer of glass frit  
15        material optionally containing an energy  
16        absorbing enhancer to a substrate to be marked  
17        in the form of a marking to be applied; and  
18        irradiating said layer with a radiant energy beam  
19        having a wavelength selected to excite the glass  
20        frit material and/or said energy absorbing  
21        enhancer, thereby forming a bonded and permanent  
22        marking layer atop the substrate which is  
23        visible in contrast with the substrate.

24       96. A thermally activated chemically based marking  
25 method comprising the steps of:

1 electrostatically applying a layer of mixed metal  
2 oxide material containing an energy absorbing  
3 enhancer to a substrate to be marked in the form  
4 of a marking to be applied; and  
5 irradiating said layer with a radiant energy beam  
6 having a wavelength selected to excite the  
7 energy absorbing enhancer, thereby forming a  
8 bonded and permanent marking layer atop the  
9 substrate which is visible in contrast with the  
10 substrate.

11 97. A thermally activated chemically based marking  
12 method comprising the steps of:

13 electrostatically applying a layer of mixed organic  
14 pigment material containing an energy absorbing  
15 enhancer to a substrate to be marked in the form  
16 of a marking to be applied; and  
17 irradiating said layer with a radiant energy beam  
18 having a wavelength selected to excite the  
19 energy absorbing enhancer, thereby forming a  
20 bonded and permanent marking layer atop the  
21 substrate which is visible in contrast with the  
22 substrate.

23 98. The method of claim 97, further comprising the step  
24 of providing a laminar air flow across the substrate during  
25 the irradiating step.



1        99. The method of claim 97, wherein the radiant energy  
2 beam further comprises a laser beam having an energy level  
3 ranging between 1 and 30 watts and a marking speed along the  
4 substrate ranging between 25 and 1000mm/sec.

5        100. The method of claim 97, wherein said irradiating  
6 step is started at a room temperature of about 70° F.

7        101. The method of claim 97, wherein said organic  
8 pigment material is applied as dry particles.

9        102. The method of claim 97, wherein said organic  
10 pigment material is applied as liquid droplets.

11       103. The method of claim 97, wherein the layer of mixed  
12 organic pigment material has a thicknes ranging between 5  
13 and 500 microns.

14       104. A substrate as marked by the process according to  
15 claim 97.

16       105. A thermally activated, chemically based marking  
17 method comprising steps of:

18        electrostatically applying a layer of a marking  
19        material comprising a Kaolin clay to a substrate  
20        to be marked; and  
21        irradiating said layer with a radiant energy beam  
22        having a wavelength selected to excite at least  
23        said Kaolin clay in accordance with the form of  
24        a marking to be applied, thereby forming a  
25        marking layer atop said substrate.

1        106. The method of claim 105, wherein said marking  
2 material further comprises an energy absorbing enhancer.

3        107. The method of claim 105, wherein said marking  
4 material is applied as dry particles.

5        108. The method of claim 105, wherein said marking  
6 material is applied as liquid droplets.

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